IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

BATAAN LICENSING LLC, Plaintiff, v. **BRIGHTSIGN LLC,** Defendant.	C.A. NO. ______________ **JURY TRIAL DEMANDED** **PATENT CASE**

ORIGINAL COMPLAINT FOR PATENT INFRINGEMENT

Plaintiff Bataan Licensing LLC files this Original Complaint for Patent Infringement against BrightSign LLC, and would respectfully show the Court as follows:

I. THE PARTIES

1. Plaintiff Bataan Licensing LLC ("Bataan" or "Plaintiff") is a Texas limited liability company having an address at 6009 W Parker Rd, Ste 149 – 1117, Plano, TX 75093.

2. On information and belief, Defendant BrightSign LLC ("Defendant") is a limited liability company organized and existing under the laws of Delaware, with a registered agent at National Registered Agents, Inc., 1209 Orange Street, Wilmington, DE 19801.

II. JURISDICTION AND VENUE

3. This action arises under the patent laws of the United States, Title 35 of the United States Code. This Court has subject matter jurisdiction of such action under 28 U.S.C. §§ 1331 and 1338(a).

4. On information and belief, Defendant is subject to this Court's specific and general personal jurisdiction, pursuant to due process and the Delaware Long-Arm Statute, due at least to its business in this forum. Furthermore, Defendant is subject to this Court's specific and general personal jurisdiction because Defendant is a Delaware limited liability company.

5. Without limitation, on information and belief, Defendant has derived revenues from its infringing acts occurring within Delaware. Further, on information and belief, Defendant is subject to the Court's general jurisdiction, including from regularly doing or soliciting business, engaging in other persistent courses of conduct, and deriving substantial revenue from goods and services provided to persons or entities in Delaware. Further, on information and belief, Defendant is subject to the Court's personal jurisdiction at least due to its sale of products and/or services within Delaware. Defendant has committed such purposeful acts and/or transactions in Delaware such that it reasonably should know and expect that it could be haled into this Court as a consequence of such activity.

6. Venue is proper in this district under 28 U.S.C. § 1400(b). On information and belief, Defendant is organized in Delaware. On information and belief, from and within this District Defendant has committed at least a portion of the infringements at issue in this case.

7. For these reasons, personal jurisdiction exists and venue is proper in this Court under 28 U.S.C. § 1400(b).

III. COUNT I
(PATENT INFRINGEMENT OF UNITED STATES PATENT NO. 7,174,494)

8. Plaintiff incorporates the above paragraphs herein by reference.

9. On February 6, 2007, United States Patent No. 7,174,494 ("the '494 Patent") was duly and legally issued by the United States Patent and Trademark Office. The '494 Patent is titled "Method and System for Coded Null Packet-Aided Synchronization." A true and correct copy of the '494 Patent is attached hereto as Exhibit A and incorporated herein by reference.

10. Bataan is the assignee of all right, title and interest in the '494 patent, including all rights to enforce and prosecute actions for infringement and to collect damages for all relevant

times against infringers of the ‘494 Patent. Accordingly, Bataan possesses the exclusive right and standing to prosecute the present action for infringement of the ‘494 Patent by Defendant.

11. The invention in the ‘494 Patent relates to the field of Time Division Multiple Access (TDMA) synchronization in a Direct Sequence Spread Spectrum communication (DSSS) system. (Ex. A at col. 1:6-8). The inventor’s recognized inefficiencies of the prior art and developed an improved method for improved data transmission in TDMA DSSS systems. (*Id*. at col. 2:20-30).

12. In traditional TDMA systems, a base unit facilitates communication between other base units and multiple local terminals or handsets. (*Id.* at col. 1:21-24). The handsets and base stations are capable of transmitting and receiving data at a particular or group of frequencies. (*Id.* at col. 1:24-26). The data signal is broken up into smaller units known as time slots, which may recur during each cycle of the data signal allowing multiple data transmission sessions to take place simultaneously. (*Id*. at col. 1:26-30). Data from a mobile terminal may be transmitted in an assigned time slot, typically leaving some TDMA time slots unused. (*Id.* at col. 1:30-36). TDMA can be used within a DSSS system. (*Id.* at col. 1:37-38). A DSSS system allows for the original high powered signal to be transmitted across a wide frequency range, allowing for transmission with little interference with other signals in that frequency band. (*Id.* at col. 1:38-50).

13. Prior art methods of TDMA for synchronizing a TDMA structure of received data required decoding the data and determine the reference point in the TDMA structure. This required the system to reliably detect the boundaries of the data packet, then demodulate, decode, and process the data packet to extract relevant TDMA information. This initial step of data packet boundary detection can be difficult to perform in certain conditions, like where the signal-to-noise ratio is low. (*Id.* at col. 1:51-61). The typical method required correlating the received data signals

with an appropriate pseudo-noise sequence to determine the correlation peak locations and locking onto the data packet boundaries. This method, however, does not provide any information about the TDMA structure until the payload data has been decoded using forward error correction (FEC) technology. (*Id.* at col. 1:62-2:4). The inventors therefore developed a method that reliably determines the TDMA structure of a data signal without decoding the FEC-encoded payload data, increasing the accuracy and speed of TDMA acquisition. (*Id.* at col. 2:4-8).

14. **Direct Infringement.** Upon information and belief, Defendant has been directly infringing at least claim 19 of the '494 patent in Delaware, and elsewhere in the United States, by performing actions comprising at least performing the claimed method of interpreting a data signal broken into a plurality of time slots using the BrightSign Mobile devices ("Accused Instrumentality") (*e.g.*, https://www.brightsign.biz/digital-signage-products/brightsign-mobile).

15. The Accused Instrumentality practices a method of interpreting a data signal (e.g., cellular data frame signal over LTE network), the data signal (*e.g.*, cellular data frame signal over LTE network) being broken into a plurality of time slots (*e.g.*, an LTE data frame comprises multiple timeslots). (*E.g.*, https://www.brightsign.biz/digital-signage-products/brightsign-mobile).

BrightSign Mobile

Get Started   Datasheet

Universal connectivity with low-cost plans built for signage

Commercial INTEGRATOR 2021 BEST WINNER

Overview

BrightSign Mobile offers an all-in-one solution for reliable player connectivity where Internet access is a challenge. It includes a low-profile USB regional modem with an installed SIM card and a choice of data plans which are custom-designed for signage and exclusive to BrightSign. Our affordable & flexible data plans can easily connect your player to the cloud with confidence.

Feature & Benefits

Universal Connectivity

- Delivers reliable player connectivity where access is a challenge

Stellar Coverage

- Supplies 4G performance with two Tier 1 carriers across the USA

All-in-One Solution

- Includes a low-profile USB regional modem paired with a mobile data service supported by BrightSign

Affordable Plans

- Offers three low-cost, 6-month data plans with low minimum data requirements designed for signage

Flexible Data Options

- Supports month-to-month services and fixed data prices for both overages & scheduled content updates

Fully BrightSign-Integrated

- Provides plug & play modem setup with full support on BSN.cloud, BrightAuthor:connected & integrated partner CMS solutions

MDM-NA

$120 MSRP

USB Modem Specifications

Low-profile USB-A connected regional modem with an installed USA SIM card

Compatible on all BrightSign Series 3 & 4 players with a USB port & BrightSign AU335

(*E.g.*, https://www.brightsign.biz/application/files/4316/2070/2255/brightSignMobile-datasheet-

05102021-web.pdf).

4 Frame structure

Throughout this specification, unless otherwise noted, the size of various fields in the time domain is expressed as a number of time units $T_s = 1/(15000 \times 2048)$ seconds.

Downlink and uplink transmissions are organized into radio frames with $T_f = 307200 \times T_s = 10$ ms duration. Two radio frame structures are supported:

- Type 1, applicable to FDD,
- Type 2, applicable to TDD.

4.2 Frame structure type 2

Frame structure type 2 is applicable to TDD. Each radio frame of length $T_f = 307200 \cdot T_s = 10$ ms consists of two half-frames of length $153600 \cdot T_s = 5$ ms each. Each half-frame consists of five subframes of length $30720 \cdot T_s = 1$ ms. The supported uplink-downlink configurations are listed in Table 4.2-2 where, for each subframe in a radio frame, 'D' denotes the subframe is reserved for downlink transmissions, 'U' denotes the subframe is reserved for uplink transmissions and 'S' denotes a special subframe with the three fields DwPTS, GP and UpPTS. The length of DwPTS and UpPTS is given by Table 4.2-1 subject to the total length of DwPTS, GP and UpPTS being equal to $30720 \cdot T_s = 1$ ms. Each subframe i is defined as two slots, $2i$ and $2i+1$ of length $T_{slot} = 15360 \cdot T_s = 0.5$ ms in each subframe.

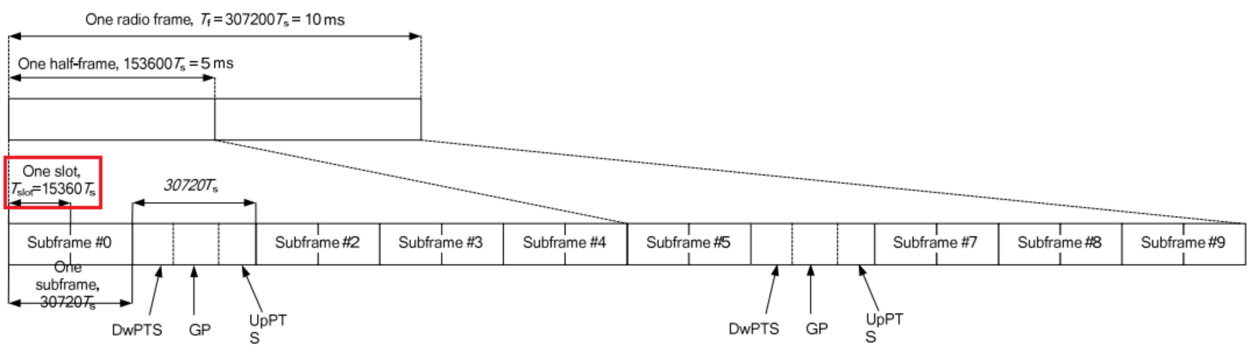

Figure 4.2-1: Frame structure type 2 (for 5 ms switch-point periodicity).

(*E.g.*, https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.09.00_60/ts_136211v080900p.pdf).

16. Upon information and belief, the Accused Instrumentality practices identifying correlation peaks (*e.g.*, correlation peaks corresponding to different symbols to identify different symbols boundary) in the data signal (*e.g.*, cellular data frame signal over LTE network), the correlation peaks corresponding to a subset of the plurality of time slots (*e.g.*, an LTE data frame having a time slot for special sub-frame), the subset of the plurality of time slots (*e.g.*, an LTE data

frame having a time slot for special sub-frame) including fixed signature data (*e.g.*, Primary Synchronization signal, sounding reference signals, etc.) representative of information about the communication system (*e.g.*, LTE communication system). (*E.g.*, https://www.brightsign.biz/digital-signage-products/brightsign-mobile).

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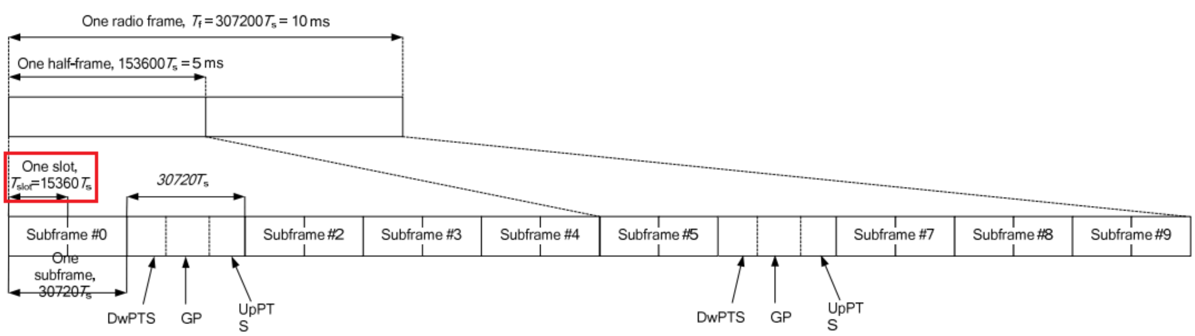

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Special subframe Details

TDD duplex mode needs to switch transmission from Downlink to Uplink and Uplink to Downlink, hence Special subframe is required for switching the transmission from Downlink to Uplink. In TDD, there are two periodicity frame one with 5ms periodicity and another with 10 ms periodicity. Special subframe is introduced at subframe #1 and subframe #6 and each half frame of 5ms carries one special subframe in case of 5ms periodicity subframe. Whereas 10 ms periodicity frame has only one Special subframe as subframe #1 . A Special subframe has three past DwPTS(Downlink Pilot Time Slot),GP (Guard Period) and UpPTS (Uplink Pilot Time Slot) and all of these have configurable lengths while the sum of the lengths has to be 1 ms or 14 symbols.

- **DwPTS** is considered as a “normal” DL subframe and carries reference signals and control information as well as data for those cases when sufficient duration is configured. It also carries PSS.
- **GP** is used to control the switching between the UL and DL transmission. Switching between transmission directions has a small hardware delay for both UE and eNodeB and needs to be compensated by GP. GP has to be large enough to cover the propagation delay of DL interferes. Its length determines the maximum supportable cell size.
- **UpPTS** is primarily intended for sounding reference signals (SRS) transmission from UE. Mainly used for RACH transmission.

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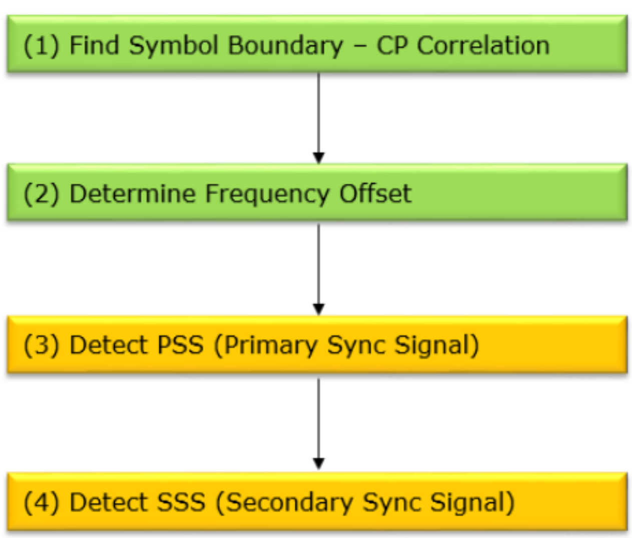
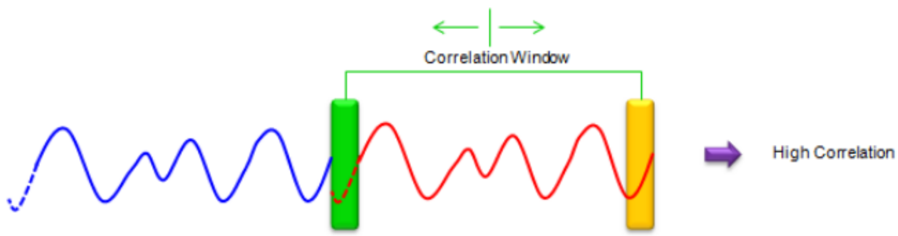
If you go into a little bit further details, you would need a couple of additional steps as follows (step (1) and step (2)). To detect PSS and SSS, you need to get the data with a sequence of specific resource elements accurately. To accurately extract the data from a specific resource elements, you need to know the exact symbol boundary (starting sample and ending sample of an OFDM symbol). Once you detect the exact symbol boundary, you can detect the frequency offset (a kind of frequency error) to further compenstate the signal. In some sense, these two steps are more difficult than PSS, SSS detection.



(*E.g.*, https://www.sharetechnote.com/html/BasicProcedure_LTE_TimeSync.html).

You may use different techniques for detecting the symbol boundary, but one of the common techniques being used is to use the property of Cyclic prefix. As you know, Cyclic Prefix is a copy of a sequence of data from the ending part of an OFDM symbol. It means that the correlation between a cyclic prefix and the ending part of a symbol should be very large comparing to other region as illustracted below.



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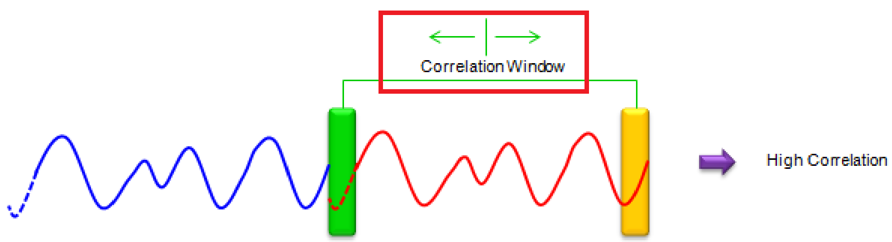
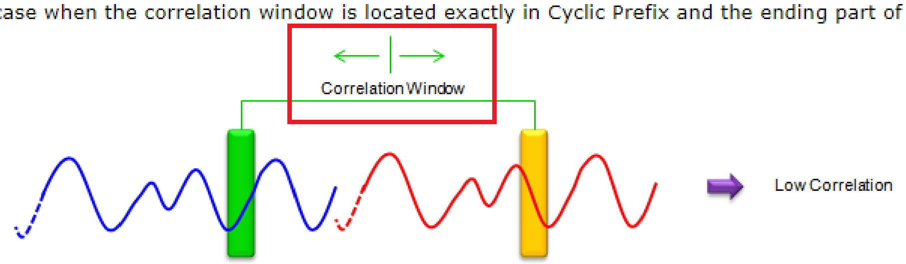


< Fig 1 : a case when the correlation window is located exactly in Cyclic Prefix and the ending part of the symbol >



< Fig 2 : a case when the correlation window is not at the position of Cyclic Prefix and the ending part of the symbol >

Using this properly, if you find the point where you get the highest correlation while you are sliding down the two correlation windows along the captured time domain data. You can find the symbol boundary.

Following is an example of plotting these correlations while sliding the windows sample by sample. You can obviously see the peaks with the interval of one OFDM Symbol (this is from the 5 Mhz BW LTE Downlink data sampled at 7.62 Mhz sampling rate).

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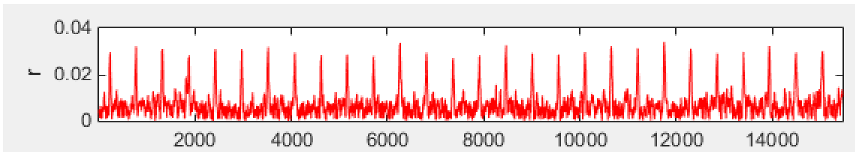

So far so good ? Sound simple ?
Maybe. But nothing goes like textbook in real engineering. Even though the cyclic prefix should be identical to the ending part of a symbol, in reality it would not be exactly same because different noise (or fading) has been applied while the signal is generated and travels through the signal path. So the correlation peak may now show up exactly at the expected point. Also the peak value may not be at only one point.. you may see similar high correlation around several samples around the peak. So you would have some errors of the location of the peaks in several samples. The accuracy of these correlation peak would be more accurate as the length of correlation window gets longer. It means you may have pretty good accuracy in wider bandwidth because CP length is longer in wider bandwidth. However, the accuracy of the correlation gets poorer as system bandwidth gets narrower since CP length gets shorter. Therefore, in real implementation, you would need some additional tricks to compensate this kind of errors.

(*E.g.*, https://www.sharetechnote.com/html/BasicProcedure_LTE_TimeSync.html).

17. Upon information and belief, the Accused Instrumentality practices associating logical values (*e.g.*, binary values corresponding to different symbols) with the correlation peaks (*e.g.*, correlation peaks corresponding to different symbols to identify different symbols boundary) and decoding the logical values (*e.g.*, binary values corresponding to different symbols) to obtain the information about the communication system (*e.g.*, LTE communication system). An LTE user equipment or base station decodes the values received over the LTE data frame signal and obtain information (*e.g.*, synchronization signals, reference signals, etc.) about LTE communication system transmitted over LTE network. As shown below, the symbols are identified at correlation peaks. (*E.g.*, https://www.brightsign.biz/digital-signage-products/brightsign-mobile).

4.2 Frame structure type 2

Frame structure type 2 is applicable to TDD. Each radio frame of length $T_f = 307200 \cdot T_s = 10$ ms consists of two half-frames of length $153600 \cdot T_s = 5$ ms each. Each half-frame consists of five subframes of length $30720 \cdot T_s = 1$ ms. The supported uplink-downlink configurations are listed in Table 4.2-2 where, for each subframe in a radio frame, 'D' denotes the subframe is reserved for downlink transmissions, 'U' denotes the subframe is reserved for uplink transmissions and 'S' denotes a special subframe with the three fields DwPTS, GP and UpPTS. The length of DwPTS and UpPTS is given by Table 4.2-1 subject to the total length of DwPTS, GP and UpPTS being equal to $30720 \cdot T_s = 1$ ms. Each subframe i is defined as two slots, $2i$ and $2i+1$ of length $T_{slot} = 15360 \cdot T_s = 0.5$ ms in each subframe.

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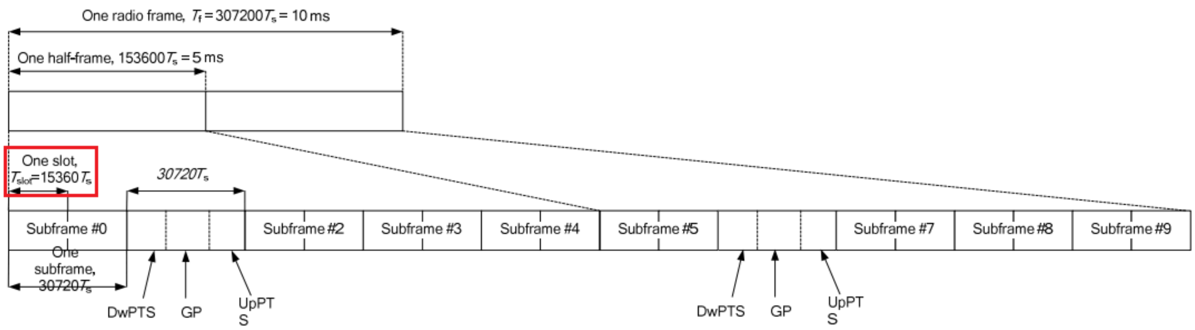

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TDD duplex mode needs to switch transmission from Downlink to Uplink and Uplink to Downlink, hence Special subframe is required for switching the transmission from Downlink to Uplink. In TDD, there are two periodicity frame one with 5ms periodicity and another with 10 ms periodicity. Special subframe is introduced at subframe #1 and subframe #6 and each half frame of 5ms carries one special subframe in case of 5ms periodicity subframe. Whereas 10 ms periodicity frame has only one Special subframe as subframe #1 . A Special subframe has three past DwPTS(Downlink Pilot Time Slot),GP (Guard Period) and UpPTS (Uplink Pilot Time Slot) and all of these have configurable lengths while the sum of the lengths has to be 1 ms or 14 symbols.

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- **UpPTS** is primarily intended for sounding reference signals (SRS) transmission from UE. Mainly used for RACH transmission.

(*E.g.*, http://www.techplayon.com/lte-tdd-special-subframe-and-its-significance-for-cell-size/).

PSS (Primary Synchronization Channel)

PSS is a specific physical layer signal that is used for radio frame synchronization. It has characterstics as listed below.

- Mapped to 72 active sub carriers(6 resource blocks), centered around the DC subcarrier in slot 0 (Subframe 0) and slot 10 (Subframe 5) in FDD.
- Mapped to 72 active sub carriers(6 resource blocks), centered around the DC subcarrier in slot 2 (Subframe 2) and slot 12 (Subframe 6) in TDD.
- Made up of 62 Zadoff Chu Sequence Values
- Used for Downlink Frame Synchronization
- One of the critical factors determining Physical Cell ID

(*E.g.*, https://www.sharetechnote.com/html/Handbook_LTE_PSS.html).

6.11 Synchronization signals

There are 504 unique physical-layer cell identities. The physical-layer cell identities are grouped into 168 unique physical-layer cell-identity groups, each group containing three unique identities. The grouping is such that each physical-layer cell identity is part of one and only one physical-layer cell-identity group. A physical-layer cell identity $N_{\mathrm{ID}}^{\mathrm{cell}} = 3N_{\mathrm{ID}}^{(1)} + N_{\mathrm{ID}}^{(2)}$ is thus uniquely defined by a number $N_{\mathrm{ID}}^{(1)}$ in the range of 0 to 167, representing the physical-layer cell-identity group, and a number $N_{\mathrm{ID}}^{(2)}$ in the range of 0 to 2, representing the physical-layer identity within the physical-layer cell-identity group.

6.11.1 Primary synchronization signal

6.11.1.1 Sequence generation

The sequence $d(n)$ used for the primary synchronization signal is generated from a frequency-domain Zadoff-Chu sequence according to

$$d_u(n) = \begin{cases} e^{-j\frac{\pi un(n+1)}{63}} & n = 0,1,...,30 \\ e^{-j\frac{\pi u(n+1)(n+2)}{63}} & n = 31,32,...,61 \end{cases}$$

where the Zadoff-Chu root sequence index u is given by Table 6.11.1.1-1.

Table 6.11.1.1-1: Root indices for the primary synchronization signal.

$N_{ID}^{(2)}$	Root index u
0	25
1	29
2	34

5.5.3 Sounding reference signal

5.5.3.1 Sequence generation

The sounding reference signal sequence $r^{SRS}(n) = r_{u,v}^{(\alpha)}(n)$ is defined by Section 5.5.1, where u is the PUCCH sequence-group number defined in Section 5.5.1.3 and v is the base sequence number defined in Section 5.5.1.4. The cyclic shift α of the sounding reference signal is given as

$$\alpha = 2\pi \frac{n_{SRS}^{cs}}{8},$$

where n_{SRS}^{cs} is configured for each UE by higher layers and $n_{SRS}^{cs} = 0,1,2,3,4,5,6,7$.

(*E.g.*, https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.09.00_60/ts_136211v080900p.pdf).

RS (Reference Signal) - Cell Specific

Most of the channels (e.g, PDSCH, PDCCH, PBCH etc) is for carrying a special information (a sequence of bits) and they have some higher layer channel connected to them, but Reference Signal is a special signal that exists only at PHY layer. This is not for delivering any specific information. The purpose of this Reference Signal is to deliver the reference point for the downlink power.

When UE try to figure out DL power (i.e, the power of the signal from a eNode B), it measure the power of this reference signal and take it as downlink cell power.

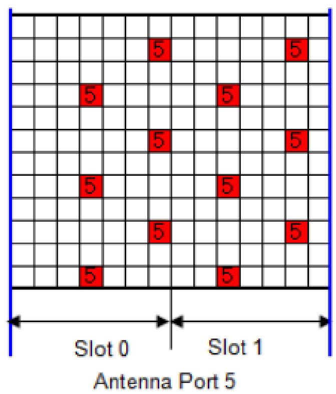
These reference signal are carried by multiples of specific Resource Elements in each slots and the location of the resource elements are specifically determined by antenna configuration.

In the figures below, Red/Blue/Green/Yellow is the part where the reference signal are carried and the resource elements marked in gray are the ones reserved for reference signal, but are not carrying Reference Signal for that specific antenna. (Follwing illustration is based on 36.211 Figure 6.10.1.2-1. Mapping of downlink reference signals (normal cyclic prefix))

RS (Reference Signal) - UE Specific

Following is based on 36.211 Figure 6.10.3.2-1: Mapping of UE-specific reference signals, antenna port 5 (normal cyclic prefix)

< Reference Signal - UE Specific - Antenna Port 5 >



(*E.g.*, https://www.sharetechnote.com/html/FrameStructure_DL.html#RS).

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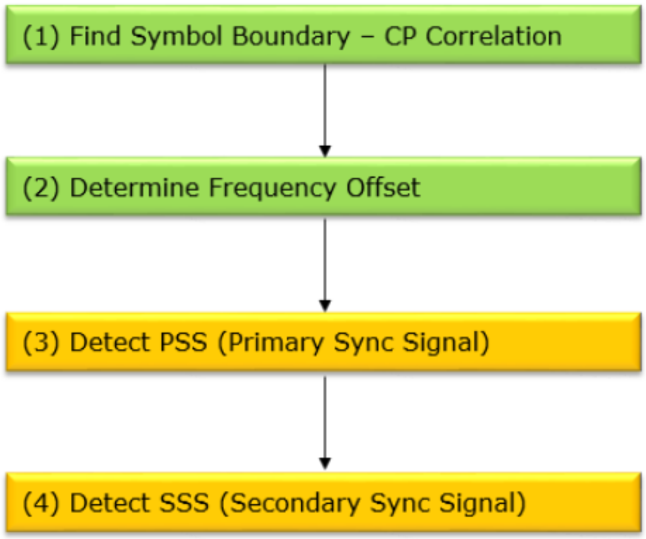

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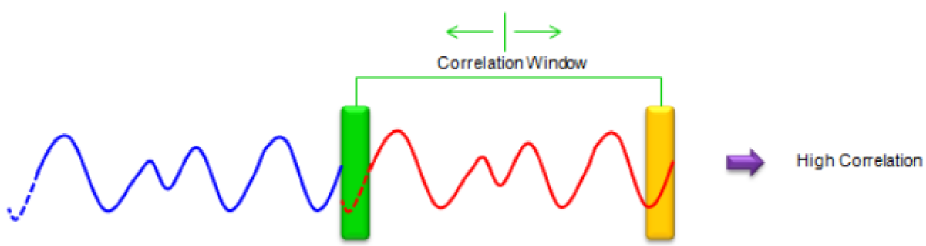

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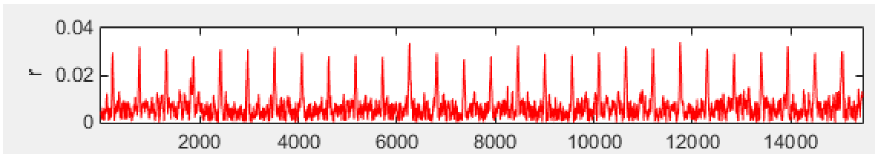

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IV. COUNT II
(PATENT INFRINGEMENT OF UNITED STATES PATENT NO. 7,423,982)

18. Plaintiff incorporates the above paragraphs herein by reference.

19. On September 9, 2008, United States Patent No. 7,423,982 ("the '982 Patent") was duly and legally issued by the United States Patent and Trademark Office. The '982 Patent is titled "Adaptive Communication Modes." A true and correct copy of the '982 Patent is attached hereto as Exhibit B and incorporated herein by reference.

20. Bataan is the assignee of all right, title and interest in the '982 patent, including all rights to enforce and prosecute actions for infringement and to collect damages for all relevant times against infringers of the '982 Patent. Accordingly, Bataan possesses the exclusive right and standing to prosecute the present action for infringement of the '982 Patent by Defendant.

21. The invention in the '982 Patent relates to the field of communications systems, more particularly to communication modes in communication systems. (Ex. B at col. 1:6-8). The inventor's recognized deficiencies of the prior art and developed an improved method of network

communication for more efficient transfer of data within a communications network. In particular, the inventors recognized that communicating using certain protocols may be slow or impaired and therefore the use of the communication device may experience delays or lack of functionality due to the slow communications. (*Id.* at col. 1:39-45). To provide the required level of service, the inventors recognized the ability of a new inventive method using quadrature phase shift keying (QPSK) and quadrature amplitude modulation (QAM) modulation schemes for communicating broadcast and unicast data to provide more effective transfer of data than prior art methods. (*Id*. at col. 5:23-34).

22. **Direct Infringement.** Upon information and belief, Defendant has been directly infringing at least claim 12 of the '982 patent in Delaware, and elsewhere in the United States, by performing actions comprising at least performing the claimed method for implementing a communication mode for a communication terminal by performing the steps of the claimed invention using the BrightSign Mobile ("Accused Instrumentality") (*e.g.*, https://www.brightsign.biz/digital-signage-products/brightsign-mobile).

23. The Accused Instrumentality practices a method for implementing a communication mode (*e.g.*, communication mode for selecting modulation schemes) for a communication terminal (*e.g.*, the Accused Instrumentality). The Accused Instrumentality supports Cellular LTE standard, which communicates with a base station using different modulation schemes. (*E.g.*, https://www.brightsign.biz/digital-signage-products/brightsign-mobile).

24. Upon information and belief, the Accused Instrumentality performs the step of receiving a message (*e.g.*, an operating mode change indication) from a remotely located network control system (*e.g.*, an LTE base station). For example, the Accused Instrumentality receives

message signals from an associated LTE base station. The base station sends a downlink control message with a DCI value over a PDCCH channel. The DCI value suggests a modulation scheme to communicate with the base station.

BrightSign Mobile

Get Started   Datasheet

Universal connectivity with low-cost plans built for signage

Overview

BrightSign Mobile offers an all-in-one solution for reliable player connectivity where Internet access is a challenge. It includes a low-profile USB regional modem with an installed SIM card and a choice of data plans which are custom-designed for signage and exclusive to BrightSign. Our affordable & flexible data plans can easily connect your player to the cloud with confidence.

Feature & Benefits

Universal Connectivity

- Delivers reliable player connectivity where access is a challenge

Stellar Coverage

- Supplies 4G performance with two Tier 1 carriers across the USA

All-in-One Solution

- Includes a low-profile USB regional modem paired with a mobile data service supported by BrightSign

Affordable Plans

- Offers three low-cost, 6-month data plans with low minimum data requirements designed for signage

Flexible Data Options

- Supports month-to-month services and fixed data prices for both overages & scheduled content updates

Fully BrightSign-Integrated

- Provides plug & play modem setup with full support on BSN.cloud, BrightAuthor:connected & integrated partner CMS solutions

MDM-NA

$120 MSRP

USB Modem Specifications

Low-profile USB-A connected regional modem with an installed USA SIM card

Compatible on all BrightSign Series 3 & 4 players with a USB port & BrightSign AU335

(*E.g.*, https://www.brightsign.biz/application/files/4316/2070/2255/brightSignMobile-datasheet-

05102021-web.pdf).

4.2.2 Physical channels and modulation

The physical channels defined in the downlink are:

- the Physical Downlink Shared Channel (PDSCH),
- the Physical Multicast Channel (PMCH),
- the Physical Downlink Control Channel (PDCCH),
- the Physical Broadcast Channel (PBCH),
- the Physical Control Format Indicator Channel (PCFICH)
- and the Physical Hybrid ARQ Indicator Channel (PHICH).

The physical channels defined in the uplink are:

- the Physical Random Access Channel (PRACH),
- the Physical Uplink Shared Channel (PUSCH),
- and the Physical Uplink Control Channel (PUCCH).

In addition, signals are defined as reference signals, primary and secondary synchronization signals.

The modulation schemes supported in the downlink and uplink are QPSK, 16QAM and 64QAM.

4.2 Downlink

Table 4.2-1 specifies the mapping of the downlink transport channels to their corresponding physical channels. Table 4.2-2 specifies the mapping of the downlink control channel information to its corresponding physical channel.

Table 4.2-1

TrCH	Physical Channel
DL-SCH	PDSCH
BCH	PBCH
PCH	PDSCH
MCH	PMCH

Table 4.2-2

Control information	Physical Channel
CFI	PCFICH
HI	PHICH
DCI	PDCCH

(*E.g.*, https://www.etsi.org/deliver/etsi_ts/136200_136299/136213/08.08.00_60/ts_136213v080800p.pdf).

5.3.3 Downlink control information

A DCI transports downlink or uplink scheduling information, or uplink power control commands for one RNTI. The RNTI is implicitly encoded in the CRC.

Figure 5.3.3-1 shows the processing structure for the DCI. The following coding steps can be identified:

- Information element multiplexing
- CRC attachment
- Channel coding
- Rate matching

The coding steps for DCI are shown in the figure below.

5.3.3.1 DCI formats

The fields defined in the DCI formats below are mapped to the information bits a_0 to a_{A-1} as follows.

Each field is mapped in the order in which it appears in the description, including the zero-padding bit(s), if any, with the first field mapped to the lowest order information bit a_0 and each successive field mapped to higher order information bits. The most significant bit of each field is mapped to the lowest order information bit for that field, e.g. the most significant bit of the first field is mapped to a_0.

Note: DCI formats 0, 1A, 3, and 3A shall have the same payload size.

(*E.g.*, https://www.etsi.org/deliver/etsi_ts/136200_136299/136213/08.08.00_60/ts_136213v080800p.pdf).

5.3.3.1.1 Format 0

DCI format 0 is used for the scheduling of PUSCH.

The following information is transmitted by means of the DCI format 0:

- Flag for format0/format1A differentiation – 1 bit, where value 0 indicates format 0 and value 1 indicates format 1A
- Hopping flag – 1 bit as defined in section 8.4 of [3]
- Resource block assignment and hopping resource allocation – $\left\lceil \log_2(N_{RB}^{UL}(N_{RB}^{UL}+1)/2) \right\rceil$ bits
- For PUSCH hopping:
  - N_{UL_hop} MSB bits are used to obtain the value of $\tilde{n}_{PRB}(i)$ as indicated in subclause [8.4] of [3]
  - $\left(\left\lceil \log_2(N_{RB}^{UL}(N_{RB}^{UL}+1)/2) \right\rceil - N_{UL\_hop} \right)$ bits provide the resource allocation of the first slot in the UL subframe
- For non-hopping PUSCH:
  - $\left(\left\lceil \log_2(N_{RB}^{UL}(N_{RB}^{UL}+1)/2) \right\rceil \right)$ bits provide the resource allocation in the UL subframe as defined in section 8.1 of [3]
- Modulation and coding scheme and redundancy version – 5 bits as defined in section 8.6 of [3]
- New data indicator – 1 bit
- TPC command for scheduled PUSCH – 2 bits as defined in section 5.1.1.1 of [3]

(*E.g.*, https://www.etsi.org/deliver/etsi_ts/136200_136299/136213/08.08.00_60/ts_136213v080800p.pdf).

5.3.3.1.3 Format 1A

DCI format 1A is used for the compact scheduling of one PDSCH codeword and random access procedure initiated by a PDCCH order.

The following information is transmitted by means of the DCI format 1A:

- Flag for format0/format1A differentiation – 1 bit, where value 0 indicates format 0 and value 1 indicates format 1A

Format 1A is used for random access procedure initiated by a PDCCH order only if format 1A CRC is scrambled with C-RNTI and all the remaining fields are set as follows:

- Localized/Distributed VRB assignment flag – 1 bit is set to '0'
- Resource block assignment – $\left\lceil \log_2(N_{RB}^{DL}(N_{RB}^{DL}+1)/2) \right\rceil$ bits, where all bits shall be set to 1
- Preamble Index – 6 bits
- PRACH Mask Index – 4 bits, [5]
- All the remaining bits in format 1A for compact scheduling assignment of one PDSCH codeword are set to zeroes

- Modulation and coding scheme – 5bits as defined in section 7.1.7 of [3]
- HARQ process number – 3 bits (FDD) , 4 bits (TDD)
- New data indicator – 1 bit
  - If the format 1A CRC is scrambled by RA-RNTI, P-RNTI, or SI-RNTI:
    - If $N_{RB}^{DL} \geq 50$ and Localized/Distributed VRB assignment flag is set to 1
      - the new data indicator bit indicates the gap value, where value 0 indicates $N_{gap} = N_{gap,1}$ and value 1 indicates $N_{gap} = N_{gap,2}$.
    - Else the new data indicator bit is reserved.
  - Else
    - The new data indicator bit as defined in [5]

(*E.g.*, https://www.etsi.org/deliver/etsi_ts/136200_136299/136213/08.08.00_60/ts_136213v080800p.pdf).

7.1.7 Modulation order and transport block size determination

To determine the modulation order and transport block size(s) in the physical downlink shared channel, the UE shall first

- read the 5-bit "modulation and coding scheme" field (I_{MCS}) in the DCI

and second if the DCI CRC is scrambled by P-RNTI, RA-RNTI, or SI-RNTI then

- for DCI format 1A:
  - o set the Table 7.1.7.2.1-1 column indicator N_{PRB} to N_{PRB}^{1A} from Section 5.3.3.1.3 in [4]
- for DCI format 1C:
  - o use Table 7.1.7.2.3-1 for determining its transport block size.

else

- set the Table 7.1.7.2.1-1 column indicator N'_{PRB} to the total number of allocated PRBs based on the procedure defined in Section 7.1.6.

  if the transport block is transmitted in DwPTS of the special subframe in frame structure type 2, then

  set the Table 7.1.7.2.1-1 column indicator $N_{PRB} = \max\{\lfloor N'_{PRB} \times 0.75 \rfloor, 1\}$,

  else, set the Table 7.1.7.2.1-1 column indicator $N_{PRB} = N'_{PRB}$.

(*E.g.*, https://www.etsi.org/deliver/etsi_ts/136200_136299/136213/08.08.00_60/ts_136213v080800p.pdf).

25. Upon information and belief, the Accused Instrumentality practices, responsive to the message specifying a first communication mode (*e.g.*, a communication mode with QPSK modulation scheme), implementing the first communication mode (*e.g.*, a communication mode with QPSK modulation scheme) including communication with the network control system using a first type of modulation scheme, wherein the first type of modulation scheme is quadrature phase shift keying (QPSK), and wherein implementing the first communication mode includes receiving broadcast data and transmitting and receiving unicast data using the first type of modulation scheme. The Accused Instrumentality receives a message with a DCI value. The DCI value suggests modulation scheme to communicate with the base station. When a DCI value indicates a QPSK modulation scheme, the Accused Instrumentality communicates with the base station utilizing QPSK modulation scheme. The Accused Instrumentality communicates broadcast and unicast messages utilizing QPSK modulation. As shown below, when the Accused Instrumentality determines the modulation order is 2 based on a DCI value or a DCI CRC scrambling interpretation. The Accused Instrumentality utilizes QPSK modulation for communication with a base station and utilizes QPSK modulation scheme for uplink and downlink communication.

5.3.3 Downlink control information

A DCI transports downlink or uplink scheduling information, or uplink power control commands for one RNTI. The RNTI is implicitly encoded in the CRC.

Figure 5.3.3-1 shows the processing structure for the DCI. The following coding steps can be identified:

- Information element multiplexing
- CRC attachment
- Channel coding
- Rate matching

The coding steps for DCI are shown in the figure below.

5.3.3.1 DCI formats

The fields defined in the DCI formats below are mapped to the information bits a_0 to a_{A-1} as follows.

Each field is mapped in the order in which it appears in the description, including the zero-padding bit(s), if any, with the first field mapped to the lowest order information bit a_0 and each successive field mapped to higher order information bits. The most significant bit of each field is mapped to the lowest order information bit for that field, e.g. the most significant bit of the first field is mapped to a_0.

Note: DCI formats 0, 1A, 3, and 3A shall have the same payload size.

(*E.g.*, https://www.etsi.org/deliver/etsi_ts/136200_136299/136213/08.08.00_60/ts_136213v080800p.pdf).

5.3.3.1.3 Format 1A

DCI format 1A is used for the compact scheduling of one PDSCH codeword and random access procedure initiated by a PDCCH order.

The following information is transmitted by means of the DCI format 1A:

- Flag for format0/format1A differentiation – 1 bit, where value 0 indicates format 0 and value 1 indicates format 1A

Format 1A is used for random access procedure initiated by a PDCCH order only if format 1A CRC is scrambled with C-RNTI and all the remaining fields are set as follows:

- Localized/Distributed VRB assignment flag – 1 bit is set to '0'
- Resource block assignment – $\lceil \log_2(N_{RB}^{DL}(N_{RB}^{DL}+1)/2) \rceil$ bits, where all bits shall be set to 1
- Preamble Index – 6 bits
- PRACH Mask Index – 4 bits, [5]
- All the remaining bits in format 1A for compact scheduling assignment of one PDSCH codeword are set to zeroes

- Modulation and coding scheme – 5bits as defined in section 7.1.7 of [3]
- HARQ process number – 3 bits (FDD) , 4 bits (TDD)
- New data indicator – 1 bit
  - If the format 1A CRC is scrambled by RA-RNTI, P-RNTI, or SI-RNTI:
    - If $N_{RB}^{DL} \geq 50$ and Localized/Distributed VRB assignment flag is set to 1
      - the new data indicator bit indicates the gap value, where value 0 indicates $N_{gap} = N_{gap,1}$ and value 1 indicates $N_{gap} = N_{gap,2}$.
    - Else the new data indicator bit is reserved.
  - Else
    - The new data indicator bit as defined in [5]

5.3.3.1.1 Format 0

DCI format 0 is used for the scheduling of PUSCH.

The following information is transmitted by means of the DCI format 0:

- Flag for format0/format1A differentiation – 1 bit, where value 0 indicates format 0 and value 1 indicates format 1A
- Hopping flag – 1 bit as defined in section 8.4 of [3]
- Resource block assignment and hopping resource allocation – $\lceil \log_2(N_{\mathrm{RB}}^{\mathrm{UL}}(N_{\mathrm{RB}}^{\mathrm{UL}}+1)/2) \rceil$ bits
- For PUSCH hopping:
  - N_{UL_hop} MSB bits are used to obtain the value of $\tilde{n}_{PRB}(i)$ as indicated in subclause [8.4] of [3]
  - $\left(\lceil \log_2(N_{\mathrm{RB}}^{\mathrm{UL}}(N_{\mathrm{RB}}^{\mathrm{UL}}+1)/2) \rceil - N_{\mathrm{UL\_hop}}\right)$ bits provide the resource allocation of the first slot in the UL subframe
- For non-hopping PUSCH:
  - $\left(\lceil \log_2(N_{\mathrm{RB}}^{\mathrm{UL}}(N_{\mathrm{RB}}^{\mathrm{UL}}+1)/2) \rceil\right)$ bits provide the resource allocation in the UL subframe as defined in section 8.1 of [3]
- Modulation and coding scheme and redundancy version – 5 bits as defined in section 8.6 of [3]
- New data indicator – 1 bit
- TPC command for scheduled PUSCH – 2 bits as defined in section 5.1.1.1 of [3]

7.1.7 Modulation order and transport block size determination

To determine the modulation order and transport block size(s) in the physical downlink shared channel, the UE shall first

- read the 5-bit "modulation and coding scheme" field (I_{MCS}) in the DCI

and second if the DCI CRC is scrambled by P-RNTI, RA-RNTI, or SI-RNTI then

- for DCI format 1A:
  - set the Table 7.1.7.2.1-1 column indicator N_{PRB} to N_{PRB}^{1A} from Section 5.3.3.1.3 in [4]
- for DCI format 1C:
  - use Table 7.1.7.2.3-1 for determining its transport block size.

else

- set the Table 7.1.7.2.1-1 column indicator N'_{PRB} to the total number of allocated PRBs based on the procedure defined in Section 7.1.6.

  if the transport block is transmitted in DwPTS of the special subframe in frame structure type 2, then

  set the Table 7.1.7.2.1-1 column indicator $N_{PRB} = \max\left\{\lfloor N'_{\mathrm{PRB}} \times 0.75 \rfloor, 1\right\}$,

  else, set the Table 7.1.7.2.1-1 column indicator $N_{PRB} = N'_{PRB}$.

7.1.7.1 Modulation order determination

The UE shall use $Q_m = 2$ if the DCI CRC is scrambled by P-RNTI, RA-RNTI, or SI-RNTI, otherwise, the UE shall use I_{MCS} and Table 7.1.7.1-1 to determine the modulation order (Q_m) used in the physical downlink shared channel.

Table 7.1.7.1-1: Modulation and TBS index table for PDSCH

MCS Index I_{MCS}	Modulation Order Q_m	TBS Index I_{TBS}
0	2	0
1	2	1
2	2	2
3	2	3
4	2	4
5	2	5
6	2	6

8.6 Modulation order, redundancy version and transport block size determination

To determine the modulation order, redundancy version and transport block size for the physical uplink shared channel, the UE shall first

- read the 5-bit "modulation and coding scheme and redundancy version" field (I_{MCS}) in the DCI, and
- check the "CQI request" bit in DCI, and
- compute the total number of allocated PRBs (N_{PRB}) based on the procedure defined in Section 8.1, and
- compute the number of coded symbols for control information..

8.6.1 Modulation order and redundancy version determination

For $0 \le I_{MCS} \le 28$, the modulation order (Q_m) is determined as follows:

- If the UE is capable of supporting 64QAM in PUSCH and has not been configured by higher layers to transmit only QPSK and 16QAM, the modulation order is given by Q'_m in Table 8.6.1-1.
- If the UE is not capable of supporting 64QAM in PUSCH or has been configured by higher layers to transmit only QPSK and 16QAM, Q'_m is first read from Table 8.6.1-1. The modulation order is set to $Q_m = \min(4, Q'_m)$.
- If the parameter *ttiBundling* provided by higher layers is set to *TRUE*, then the resource allocation size is restricted to $N_{PRB} \le 3$ and the modulation order is set to $Q_m = 2$.

MCS and Modulation Order

You may know that MCS (Modulation Coding Scheme) is related to Modulation Order (Modulation Depth, e.g, QPSK, 16 QAM, 64 QAM, 256 QAM). This modulation order is defined as a Parameter called Qm in 3GPP and the relationship between MCS value and Qm is defined in a little bit differently for PDSCH and PUSCH in the three tables : Table 7.1.7.1-1, 7.1.7.1-1A and Table 8.6.1-1 in 36.213.

The mapping between Qm and Modulation Method is defined as follows (Following is for downlink).

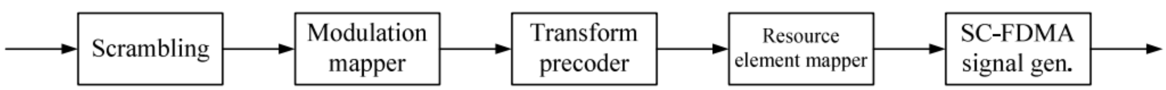
Qm	Modulation Method
2	QPSK
4	16 QAM
6	64 QAM
8	256 QAM

NOTE : If Uplink case, the meaning of Qm 6 varies a little depending UE capability. Qm 6 in UL is interpreted as 16 QAM if UE does not support 64QAM and it is interpreted as 64QAM if UE support 64QAM.

5.3 Physical uplink shared channel

The baseband signal representing the physical uplink shared channel is defined in terms of the following steps:

- scrambling
- modulation of scrambled bits to generate complex-valued symbols
- transform precoding to generate complex-valued symbols
- mapping of complex-valued symbols to resource elements
- generation of complex-valued time-domain SC-FDMA signal for each antenna port

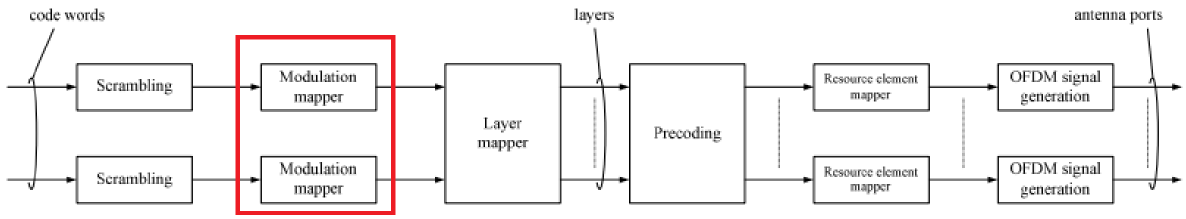


6.3 General structure for downlink physical channels

This section describes a general structure, applicable to more than one physical channel.

The baseband signal representing a downlink physical channel is defined in terms of the following steps:

- scrambling of coded bits in each of the code words to be transmitted on a physical channel
- modulation of scrambled bits to generate complex-valued modulation symbols
- mapping of the complex-valued modulation symbols onto one or several transmission layers
- precoding of the complex-valued modulation symbols on each layer for transmission on the antenna ports
- mapping of complex-valued modulation symbols for each antenna port to resource elements
- generation of complex-valued time-domain OFDM signal for each antenna port



6.6 Physical broadcast channel

6.6.1 Scrambling

The block of bits $b(0),...,b(M_{\text{bit}}-1)$, where M_{bit}, the number of bits transmitted on the physical broadcast channel, equals 1920 for normal cyclic prefix and 1728 for extended cyclic prefix, shall be scrambled with a cell-specific sequence prior to modulation, resulting in a block of scrambled bits $\tilde{b}(0),...,\tilde{b}(M_{\text{bit}}-1)$ according to

$$\tilde{b}(i) = (b(i) + c(i)) \bmod 2$$

where the scrambling sequence $c(i)$ is given by Section 7.2. The scrambling sequence shall be initialised with $c_{\text{init}} = N_{\text{ID}}^{\text{cell}}$ in each radio frame fulfilling $n_{\text{f}} \bmod 4 = 0$.

6.6.2 Modulation

The block of scrambled bits $\tilde{b}(0),...,\tilde{b}(M_{\text{bit}}-1)$ shall be modulated as described in Section 7.1, resulting in a block of complex-valued modulation symbols $d(0),...,d(M_{\text{symb}}-1)$. Table 6.6.2-1 specifies the modulation mappings applicable for the physical broadcast channel.

Table 6.6.2-1: PBCH modulation schemes

Physical channel	Modulation schemes
PBCH	QPSK

5.3.2 Modulation

The block of scrambled bits $\tilde{b}(0),...,\tilde{b}(M_{\text{bit}}-1)$ shall be modulated as described in Section 7.1, resulting in a block of complex-valued symbols $d(0),...,d(M_{\text{symb}}-1)$. Table 5.3.2-1 specifies the modulation mappings applicable for the physical uplink shared channel.

Table 5.3.2-1: Uplink modulation schemes

Physical channel	Modulation schemes
PUSCH	QPSK, 16QAM, 64QAM

(*E.g.*, https://www.etsi.org/deliver/etsi_ts/136200_136299/136213/08.08.00_60/ts_136213v080800p.pdf).

26. Upon information and belief, the Accused Instrumentality practices, responsive to the message specifying a second communication mode (*e.g.*, a communication mode with a QAM modulation scheme), implementing the second communication mode (*e.g.*, a communication mode with a QAM modulation scheme) including communicating with the network control system using a second type of modulation scheme, wherein the second type of modulation scheme is quadrature amplitude modulation (QAM). When the received DCI value indicates QAM modulation scheme, the Accused Instrumentality communicates with the base station utilizing a QAM modulation scheme. As shown below, when the Accused Instrumentality determines the modulation order is other than 2 based on a DCI value or a DCI CRC scrambling interpretation, the Accused Instrumentality utilizes a QAM modulation for communication with a base station. The Accused Instrumentality utilizes a QAM modulation scheme for the uplink and downlink communication.

5.3.3 Downlink control information

A DCI transports downlink or uplink scheduling information, or uplink power control commands for one RNTI. The RNTI is implicitly encoded in the CRC.

Figure 5.3.3-1 shows the processing structure for the DCI. The following coding steps can be identified:

- Information element multiplexing
- CRC attachment
- Channel coding
- Rate matching

The coding steps for DCI are shown in the figure below.

(*E.g.*, https://www.etsi.org/deliver/etsi_ts/136200_136299/136212/08.08.00_60/ts_136212v080800p.pdf).

5.3.3.1 DCI formats

The fields defined in the DCI formats below are mapped to the information bits a_0 to a_{A-1} as follows.

Each field is mapped in the order in which it appears in the description, including the zero-padding bit(s), if any, with the first field mapped to the lowest order information bit a_0 and each successive field mapped to higher order information bits. The most significant bit of each field is mapped to the lowest order information bit for that field, e.g. the most significant bit of the first field is mapped to a_0.

Note: DCI formats 0, 1A, 3, and 3A shall have the same payload size.

(*E.g.*, https://www.etsi.org/deliver/etsi_ts/136200_136299/136212/08.08.00_60/ts_136212v080800p.pdf).

5.3.3.1.1 Format 0

DCI format 0 is used for the scheduling of PUSCH.

The following information is transmitted by means of the DCI format 0:

- Flag for format0/format1A differentiation – 1 bit, where value 0 indicates format 0 and value 1 indicates format 1A
- Hopping flag – 1 bit as defined in section 8.4 of [3]
- Resource block assignment and hopping resource allocation – $\lceil \log_2(N_{RB}^{UL}(N_{RB}^{UL}+1)/2) \rceil$ bits
- For PUSCH hopping:
  - N_{UL_hop} MSB bits are used to obtain the value of $\tilde{n}_{PRB}(i)$ as indicated in subclause [8.4] of [3]
  - $\left(\lceil \log_2(N_{RB}^{UL}(N_{RB}^{UL}+1)/2) \rceil - N_{UL\_hop} \right)$ bits provide the resource allocation of the first slot in the UL subframe
- For non-hopping PUSCH:
  - $\left(\lceil \log_2(N_{RB}^{UL}(N_{RB}^{UL}+1)/2) \rceil \right)$ bits provide the resource allocation in the UL subframe as defined in section 8.1 of [3]

- Modulation and coding scheme and redundancy version – 5 bits as defined in section 8.6 of [3]
- New data indicator – 1 bit
- TPC command for scheduled PUSCH – 2 bits as defined in section 5.1.1.1 of [3]

(*E.g.*, https://www.etsi.org/deliver/etsi_ts/136200_136299/136212/08.08.00_60/ts_136212v080800p.pdf).

5.3.3.1.3 Format 1A

DCI format 1A is used for the compact scheduling of one PDSCH codeword and random access procedure initiated by a PDCCH order.

The following information is transmitted by means of the DCI format 1A:

- Flag for format0/format1A differentiation – 1 bit, where value 0 indicates format 0 and value 1 indicates format 1A

Format 1A is used for random access procedure initiated by a PDCCH order only if format 1A CRC is scrambled with C-RNTI and all the remaining fields are set as follows:

  - Localized/Distributed VRB assignment flag – 1 bit is set to '0'
  - Resource block assignment – $\lceil \log_2(N_{RB}^{DL}(N_{RB}^{DL}+1)/2) \rceil$ bits, where all bits shall be set to 1
  - Preamble Index – 6 bits
  - PRACH Mask Index – 4 bits, [5]
  - All the remaining bits in format 1A for compact scheduling assignment of one PDSCH codeword are set to zeroes

- Modulation and coding scheme – 5bits as defined in section 7.1.7 of [3]
- HARQ process number – 3 bits (FDD) , 4 bits (TDD)
- New data indicator – 1 bit
  - If the format 1A CRC is scrambled by RA-RNTI, P-RNTI, or SI-RNTI:
    - If $N_{RB}^{DL} \geq 50$ and Localized/Distributed VRB assignment flag is set to 1
      - the new data indicator bit indicates the gap value, where value 0 indicates $N_{gap} = N_{gap,1}$ and value 1 indicates $N_{gap} = N_{gap,2}$.
    - Else the new data indicator bit is reserved.
  - Else
    - The new data indicator bit as defined in [5]

(*E.g.*, https://www.etsi.org/deliver/etsi_ts/136200_136299/136212/08.08.00_60/ts_136212v080800p.pdf).

7.1.7 Modulation order and transport block size determination

To determine the modulation order and transport block size(s) in the physical downlink shared channel, the UE shall first

- read the 5-bit "modulation and coding scheme" field (I_{MCS}) in the DCI

and second if the DCI CRC is scrambled by P-RNTI, RA-RNTI, or SI-RNTI then

- for DCI format 1A:
  - set the Table 7.1.7.2.1-1 column indicator N_{PRB} to N_{PRB}^{1A} from Section 5.3.3.1.3 in [4]
- for DCI format 1C:
  - use Table 7.1.7.2.3-1 for determining its transport block size.

else

- set the Table 7.1.7.2.1-1 column indicator N'_{PRB} to the total number of allocated PRBs based on the procedure defined in Section 7.1.6.

  if the transport block is transmitted in DwPTS of the special subframe in frame structure type 2, then

  set the Table 7.1.7.2.1-1 column indicator $N_{PRB} = \max\{\lfloor N'_{\mathrm{PRB}} \times 0.75 \rfloor, \ 1\}$,

  else, set the Table 7.1.7.2.1-1 column indicator $N_{PRB} = N'_{PRB}$.

(*E.g.*, https://www.etsi.org/deliver/etsi_ts/136200_136299/136213/08.08.00_60/ts_136213v080800p.pdf).

7.1.7.1 Modulation order determination

The UE shall use $Q_m = 2$ if the DCI CRC is scrambled by P-RNTI, RA-RNTI, or SI-RNTI, otherwise, the UE shall use I_{MCS} and Table 7.1.7.1-1 to determine the modulation order (Q_m) used in the physical downlink shared channel.

Table 7.1.7.1-1: Modulation and TBS index table for PDSCH

MCS Index I_{MCS}	Modulation Order Q_m	TBS Index I_{TBS}
0	2	0
1	2	1
2	2	2
3	2	3
4	2	4
5	2	5
6	2	6

(*E.g.*, https://www.etsi.org/deliver/etsi_ts/136200_136299/136213/08.08.00_60/ts_136213v080800p.pdf).

7	2	7
8	2	8
9	2	9
10	4	9
11	4	10
12	4	11
13	4	12
14	4	13
15	4	14
16	4	15
17	6	15
18	6	16
19	6	17
20	6	18
21	6	19
22	6	20
23	6	21
24	6	22
25	6	23
26	6	24
27	6	25
28	6	26
29	2	reserved
30	4	
31	6	

(*E.g.*, https://www.etsi.org/deliver/etsi_ts/136200_136299/136213/08.08.00_60/ts_136213v080800p.pdf).

8.6 Modulation order, redundancy version and transport block size determination

To determine the modulation order, redundancy version and transport block size for the physical uplink shared channel, the UE shall first

- read the 5-bit "modulation and coding scheme and redundancy version" field (I_{MCS}) in the DCI, and
- check the "CQI request" bit in DCI, and
- compute the total number of allocated PRBs (N_{PRB}) based on the procedure defined in Section 8.1, and
- compute the number of coded symbols for control information..

8.6.1 Modulation order and redundancy version determination

For $0 \le I_{MCS} \le 28$, the modulation order (Q_m) is determined as follows:

(*E.g.*, https://www.etsi.org/deliver/etsi_ts/136200_136299/136213/08.08.00_60/ts_136213v080800p.pdf).

- If the UE is capable of supporting 64QAM in PUSCH and has not been configured by higher layers to transmit only QPSK and 16QAM, the modulation order is given by Q'_m in Table 8.6.1-1.
- If the UE is not capable of supporting 64QAM in PUSCH or has been configured by higher layers to transmit only QPSK and 16QAM, Q'_m is first read from Table 8.6.1-1. The modulation order is set to $Q_m = \min(4, Q'_m)$.
- If the parameter *ttiBundling* provided by higher layers is set to *TRUE*, then the resource allocation size is restricted to $N_{PRB} \leq 3$ and the modulation order is set to $Q_m = 2$.

(*E.g.*, https://www.etsi.org/deliver/etsi_ts/136200_136299/136213/08.08.00_60/ts_136213v080800p.pdf).

Table 8.6.1-1: Modulation, TBS index and redundancy version table for PUSCH

MCS Index I_{MCS}	Modulation Order Q'_m	TBS Index I_{TBS}	Redundancy Version rv_{idx}
0	2	0	0
1	2	1	0
2	2	2	0
3	2	3	0
4	2	4	0
5	2	5	0
6	2	6	0
7	2	7	0
8	2	8	0
9	2	9	0
10	2	10	0
11	4	10	0
12	4	11	0
13	4	12	0
14	4	13	0
15	4	14	0
16	4	15	0
17	4	16	0
18	4	17	0
19	4	18	0
20	4	19	0
21	6	19	0
22	6	20	0
23	6	21	0
24	6	22	0
25	6	23	0
26	6	24	0
27	6	25	0
28	6	26	0
29	reserved		1
30			2
31			3

(*E.g.*, https://www.etsi.org/deliver/etsi_ts/136200_136299/136213/08.08.00_60/ts_136213v080800p.pdf).

MCS and Modulation Order

You may know that MCS (Modulation Coding Scheme) is related to Modulation Order (Modulation Depth, e.g, QPSK, 16 QAM, 64 QAM, 256 QAM). This modulation order is defined as a Parameter called Qm in 3GPP and the relationship between MCS value and Qm is defined in a little bit differently for PDSCH and PUSCH in the three tables : Table 7.1.7.1-1, 7.1.7.1-1A and Table 8.6.1-1 in 36.213.

The mapping between Qm and Modulation Method is defined as follows (Following is for downlink).

Qm	Modulation Method
2	QPSK
4	16 QAM
6	64 QAM
8	256 QAM

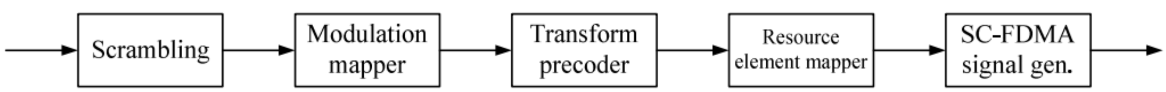
NOTE : If Uplink case, the meaning of Qm 6 varies a little depending UE capability. Qm 6 in UL is interpreted as 16 QAM if UE does not support 64QAM and it is interpreted as 64QAM if UE support 64QAM.

(*E.g.*, https://www.sharetechnote.com/html/Handbook_LTE_MCS_ModulationOrder.html).

5.3 Physical uplink shared channel

The baseband signal representing the physical uplink shared channel is defined in terms of the following steps:

- scrambling
- modulation of scrambled bits to generate complex-valued symbols
- transform precoding to generate complex-valued symbols
- mapping of complex-valued symbols to resource elements
- generation of complex-valued time-domain SC-FDMA signal for each antenna port



5.3.2 Modulation

The block of scrambled bits $\tilde{b}(0),...,\tilde{b}(M_{\text{bit}}-1)$ shall be modulated as described in Section 7.1, resulting in a block of complex-valued symbols $d(0),...,d(M_{\text{symb}}-1)$. Table 5.3.2-1 specifies the modulation mappings applicable for the physical uplink shared channel.

Table 5.3.2-1: Uplink modulation schemes

Physical channel	Modulation schemes
PUSCH	QPSK, 16QAM, 64QAM

(*E.g.*, https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.09.00_60/ts_136211v080900p.pdf).

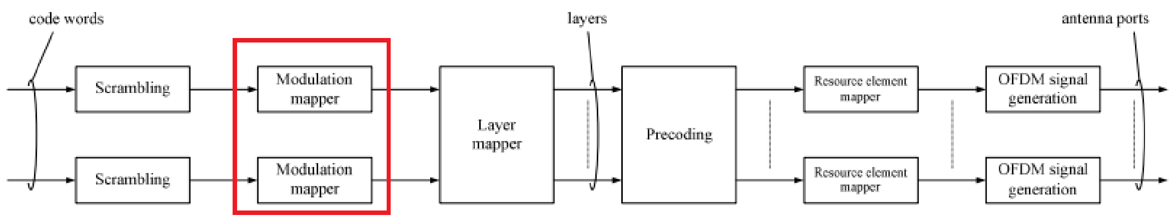
6.3 General structure for downlink physical channels

This section describes a general structure, applicable to more than one physical channel.

The baseband signal representing a downlink physical channel is defined in terms of the following steps:

- scrambling of coded bits in each of the code words to be transmitted on a physical channel
- modulation of scrambled bits to generate complex-valued modulation symbols
- mapping of the complex-valued modulation symbols onto one or several transmission layers
- precoding of the complex-valued modulation symbols on each layer for transmission on the antenna ports
- mapping of complex-valued modulation symbols for each antenna port to resource elements
- generation of complex-valued time-domain OFDM signal for each antenna port

(*E.g.*, https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.09.00_60/ts_136211v080900p.pdf).



6.3.2 Modulation

For each code word q, the block of scrambled bits $\tilde{b}^{(q)}(0),...,\tilde{b}^{(q)}(M_{\text{bit}}^{(q)}-1)$ shall be modulated as described in Section 7.1 using one of the modulation schemes in Table 6.3.2-1, resulting in a block of complex-valued modulation symbols $d^{(q)}(0),...,d^{(q)}(M_{\text{symb}}^{(q)}-1)$.

Table 6.3.2-1: Modulation schemes

Physical channel	Modulation schemes
PDSCH	QPSK, 16QAM, 64QAM
PMCH	QPSK, 16QAM, 64QAM

(*E.g.*, https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.09.00_60/ts_136211v080900p.pdf).

27. Plaintiff has been damaged as a result of Defendant's infringing conduct. Defendant is thus liable to Plaintiff for damages in an amount that adequately compensates

Plaintiff for such Defendant's infringement of the '494 patent and '982 patent, *i.e.*, in an amount that by law cannot be less than would constitute a reasonable royalty for the use of the patented technology, together with interest and costs as fixed by this Court under 35 U.S.C. § 284.

28. On information and belief, Defendant has had at least constructive notice of the '494 Patent, and '982 Patent, by operation of law and marking requirements have been complied with.

V. JURY DEMAND

Plaintiff, under Rule 38 of the Federal Rules of Civil Procedure, requests a trial by jury of any issues so triable by right.

VI. PRAYER FOR RELIEF

WHEREFORE, Plaintiff respectfully requests that the Court find in its favor and against Defendant, and that the Court grant Plaintiff the following relief:

a. Judgment that one or more claims of United States Patent No. 7,174,494 have been infringed, either literally and/or under the doctrine of equivalents, by Defendant;

b. Judgment that one or more claims of United States Patent No. 7,423,982 have been infringed, either literally and/or under the doctrine of equivalents, by Defendant;

c. Judgment that Defendant account for and pay to Plaintiff all damages to and costs incurred by Plaintiff because of Defendant's infringing activities and other conduct complained of herein;

d. That Plaintiff be granted pre-judgment and post-judgment interest on the damages caused by Defendant's infringing activities and other conduct complained of herein;

e. That Plaintiff be granted such other and further relief as the Court may deem just and proper under the circumstances.

July 27, 2021

OF COUNSEL:

David R. Bennett
Direction IP Law
P.O. Box 14184
Chicago, IL 60614-0184
(312) 291-1667
dbennett@directionip.com

CHONG LAW FIRM P.A.

/s/ Jimmy Chong

Jimmy Chong (#4839)
2961 Centerville Road, Suite 350
Wilmington, DE 19808
Telephone: (302) 999-9480
Facsimile: (302) 800-1999
Email: chong@chonglawfirm.com

Attorneys for Plaintiff Bataan Licensing LLC